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FULL-SCALE ROOM FIRE EXPERIMENTS

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Full-Scale Room Fire Experiments

Conducted at the University of Maryland

Test Report

to

National Institute of Standards and Technology

by

Amy J. McGarry and James A. Milke

Department of Fire Protection Engineering

University of Maryland at College Park

March 17, 1997

I. Burn #1, September 19, 1996
Burn Tower, Training Academy, Maryland Fire & Rescue Institute
University of Maryland

1.1 Description of Test Facility

1.1.1 Room Description

The room was located on the first floor of the burn tower. Dimensions of the room were 3,660 mm x 3,660 mm, with a height of 2,440 mm. There was a single door opening to the room centered on the East wall, with a width of 910 mm and height 2,090 mm. The door was opened during the test. A single, double-hung window was centered on the North wall of the room, with the bottom of the frame located 908 mm above the floor. The window had one pane of glass, 578 mm wide and 374 mm in height. The outside dimensions of the window frame were 864 mm wide and 1,118 mm in height. The window was closed during the test.

1.1.2 Furniture Plan

The furniture in the room included the items listed in Table 1.1. The relative locations of the furniture are indicated in Figure 1.1. The mass of the furnishings is indicated in Table 1.2.

1.1.3 Floor Plan

The concrete slab was covered with plywood. On top of the plywood a hardwood, no-wax, pre-sealed, urethane-finish parquet flooring was placed. The hardwood flooring covered a 3,048 mm x 3,048 mm area starting from the center of the W wall. The 304.8 mm x 304.8 mm x 7.9 mm flooring tiles were glued on top of the plywood. Each flooring piece weighed 4.54 kg. Therefore, with one hundred flooring tiles used, the overall weight of the flooring was 454 kg.

1.2. Instrumentation

Temperature, heat flux, and oxygen sampling measurements were obtained. Locations of the instrumentation are described in the following sections and are depicted in Figure 1.2.

1.2.1 Thermocouples

Thermocouple trees were placed at the locations noted in Table 1.3. Thermocouples were also placed under the hardwood flooring, as shown in Figure 1.2. The thermocouples placed under the floor were approximately 4 mm from the top surface. Thermocouple 10

was the only thermocouple exposed to the gasoline, protruding about 6.4 mm above the floor.

Table 1.1

Furniture Item	**Description**
Single Bed	1,820 mm x 910 mm x 560 mm box springs, mattress raised on metal frame, fully made with sheets, bedspread (polymer composition, probably polyurethane), blanket, comforter, and pillow located in NW corner of room
Armchair	970 mm wide x 910 mm deep (410 mm high at seat, 610 mm high at back) located flush against W wall, 410 mm from bed
Dresser	1,320 mm x 460 mm x 760 mm located in SW corner, 25 mm off S wall and 30 mm off W wall Porcelain lamp w/ bulb plugged in (not energized) centered on dresser Lamp: 610 mm high, base diameter of 165 mm
Wastebasket	plastic wastebasket 380 mm high 300 mm x 180 mm footprint
End Table	530 mm x 220 mm x 550 mm located 440 mm off E wall, 51 mm off N wall Same size lamp with bulb plugged into wall (energized)
Flooring	plywood floor 3,048 mm x 3,048 mm area off W wall genuine hardwood, no-wax, pre-sealed urethane finish flooring on top of plywood 7.9 mm thickness

Note: The dimensions of the lamp and the wastebasket are approximate.

1.2.2 Heat Flux Meters

Two heat flux meters were provided in the room, pointed in the horizontal direction. One was located immediately above the end table, 578 mm above the floor and 787 mm from the E wall, and the other one foot above, 883 mm above the floor and 787 mm from the E wall. The heat flux meters were water-cooled and placed directly through the gypsum wallboard layer comprising the wall.

Table 1.2

Item		Mass (kg)
Bed	Box spring	50.0
	Frame, metal (12.5 kg)	
	Headboard	
	Mattress	
Bedding	Bedspread	4.5
	Blanket	
	Pillow	
	Pillow Case	
	Sheet, Bottom	
	Sheet, Top	
Flooring		453.6
Chair		32.0
Dresser		42.0
Lamp, Porcelain with 60 W Bulb		2.5
Lamp, Metal with 60 W Bulb		3.0
Night Table		15.0
Waste Basket, Plastic		0.6
Total		603.2

Note: The mass of both lamps and the waste basket are approximate.

Table 1.3

Trees	Location	Thermocouple Placement
A	Center of Room	top at 2,440 mm with 305 mm increments
B	Window	305 mm off N wall, 305 mm from left of window frame (as viewed from the inside) top at 2,440 mm with 305 mm increments Note: The tree was not perfectly vertical, because of the bed interference. Approximately three feet from the floor the tree shifted approximately 38.1 mm from the centerline.

1.2.3 Gas Sampling Probes

Gas sampling probes to monitor O_2 concentrations were included at the following locations in the room:

(1) On N wall, 1,305 mm from the E wall, between the end table and bed, 721 mm above the floor.

(1) Doorway, 305 mm above the floor, 305 mm from the E side of the door opening.

Oxygen concentrations from the analyzer collecting data on the N wall appeared to indicate very low readings along with negative readings. It was concluded that the analyzer was not working properly. Therefore, the data was disregarded.

1.2.5 Video Cameras

A videotape record was made of the test from ground level, in the doorway, facing the chair and bed.

1.3 Procedure

The fire was initiated by pouring a quart of gasoline, centered around thermocouple 10, on the floor. The pool was ignited with a propane torch. Coincidently, a switch was closed to indicate ignition on the data acquisition system.

1.4 Data

Data collected during the test is included in Figures 1.3 to 1.7. Table 1.4 summarizes the presentation of the data in the seven figures. A tabulation of the data is presented in the appendix. Visual observations were noted on the audio track of the videotape records.

Table 1.4

Measurement	Figure
Temperature at Window	1.3
Temperature in Middle of Room	1.4
Temperature Under the Floor	1.5
Heat Flux	1.6
Oxygen Concentration	1.7

II. Burn #2, September 19, 1996
Burn Tower, Training Academy, Maryland Fire & Rescue Institute
University of Maryland

2.1 Description of Test Facility

2.1.1 Room Description

The room was located on the first floor of the burn tower. Dimensions of the room were 3,660 mm x 3,660 mm, with a height of 2,440 mm. There was a single door opening to the room centered on the North wall, with a width of 910 mm and height 2,090 mm. The door was left open during the test. A single, double-hung window was located on the W wall of the room, with the bottom of the frame located 903 mm above the floor. The window had 2 panes of glass, each 578 mm wide and 378 mm in height. The outside dimensions of the window frame were 864 mm wide and 1,118 mm in height. The window was closed during the test.

2.1.2 Furniture Plan

The furniture in the room included the items listed in Table 2.1. The relative locations of the furniture are indicated in Figure 2.1.

2.1.3 Floor Plan

The concrete slab was covered with plywood. On top of the plywood a hardwood, no-wax, pre-sealed, urethane-finish parquet flooring was placed. The hardwood flooring covered a 2,896 mm x 3.048 mm area starting from the center of the S wall. The 304.8 mm x 304.8 mm x 7.9 mm flooring tiles were glued on top of the plywood. Each flooring piece weighed 4.54 kg. Therefore, with one hundred flooring tiles used, the overall weight of the flooring was 454 kg.

2.2 Instrumentation

Temperature, heat flux, pressure flows and oxygen sampling measurements were obtained. Locations of the instrumentation are described in the following sections and are depicted in Figure 2.2.

2.2.1 Thermocouples

Thermocouple trees were placed at the locations noted in Table 2.3. Thermocouples were also placed under the hardwood flooring, as shown in Figure 2.2. The thermocouples placed under the floor were approximately 4 mm from the top surface. Thermocouple 10

was the only thermocouple exposed to the gasoline, protruding about 6.4 mm above the floor.

Table 2.1

Furniture Item	**Description**
Single Bed	1,820 mm x 910 mm x 560 mm box springs, mattress raised on metal frame, fully made with sheets, bedspread (polymer composition, probably polyurethane), blanket, comforter, and pillow located in SW corner of room
Armchair	970 mm wide x 910 mm deep (410 mm high at seat, 610 mm high at back) located flush against S wall, 410 mm from bed
Dresser	1,320 mm x 460 mm x 760 mm located in SE corner, 25 mm off E wall and 305 mm off S wall Both metal lamps w/ bulb one plugged in (not energized), and the other not plugged in, were on dresser Lamps: 627 mm high, base diameter of 159 mm
Wastebasket	plastic wastebasket 380 mm high 305 mm x 180 mm footprint
End Table	530 mm x 220 mm x 550 mm located 440 mm off N wall, 51 mm off W wall
Flooring	plywood floor 2,896 mm x 3,048 mm area off S wall genuine hardwood, no-wax, pre-sealed urethane finish flooring on top of plywood glue used

Note: The second room is constructed as a duplicate of the first burn room, except the lamps are not energized and the orientation of the room in plan view is rotated 90° due to the characteristics of the burn tower enclosure. The mass of the furnishings is indicated in Table 2.2.

The largest difference is the volume outside of openings in the rooms. The volume near the door in the first test was close to a door leading outside of the burn building. In the second test, the door was close to an outside leading door and also an open stairwell.

The dimensions of the lamp and the wastebasket are approximate.

Table 2.2

Trees	Location	Thermocouple Placement
A	Center of Room	top at 2,440 mm with 305 mm increments
B	Window	305 mm off E wall, 305 mm from left of window frame (as viewed from the inside) top at 2,440 mm with 305 mm increments Note: The tree was not perfectly vertical, because of the bed interference. Approximately three feet from the floor the tree shifted approximately 38.1 mm from the centerline.

2.2.2 Heat Flux Meters

Two heat flux meters were provided in the room, pointed in the horizontal direction. One was located immediately above the end table 581 mm above the floor and 806 mm from the north wall, and the other one foot above, 886 mm above the floor and 792 mm from the north wall. The heat flux meters were water-cooled and placed directly through gypsum wallboard layer comprising the wall.

2.2.3 Gas Sampling Probes

Gas sampling probes to monitor O_2 concentrations were included at the following locations in the room:

(1) On the W wall, 1,318 mm from the N wall, between the bed and end table, and 727 mm above the floor.

(1) Doorway, 305 mm above the floor, 305 mm from the east side of the door opening, measuring O_2 (separate instrument not recorded in data file).

Oxygen concentrations from the analyzer, collecting data on the W wall appeared to indicate very low readings along with negative readings. It was concluded that the analyzer was not working properly. Oxygen concentrations from the analyzer collecting data at the doorway remained steady during the test at 20.9 percent. Therefore, both sets of data were disregarded.

2.2.4 Pressure Gauge

A pressure reading was taken 102 mm S from the window pane, 1,245 mm above the floor. The gauge indicated the pressure difference between the inside of the room and the outside. This reading was taken by equipment supplied by Bob Levin.

2.2.5 Video Cameras

A videotape record was made of the test from ground level, in the doorway, facing the chair and bed.

2.3 Procedure

The fire was initiated by pouring a quart of gasoline, centered around thermocouple 10, on the floor. The pool was ignited with a propane torch. Coincidently, a switch was closed to indicate ignition on the data acquisition system.

2.4 Data

Data collected during the test is included in Figures 2.3 to 2.7. Table 2.3 summarizes the presentation of the data in the seven figures. Unfortunately, 2 minutes and 11 seconds int o the test, electrical power was lost. Therefore, no data was collected from that point on. The fire continued and was suppressed at three minutes after flashover. Visual observations were noted of the audio track on the videotape records.

Table 2.3

Measurement	Figure
Temperature at Window	2.3
Temperature in Middle of Room	2.4
Temperature Under the Floor	2.5
Heat Flux	2.6
Pressure Gauge	2.7

Note: Heat flux readings for the meter located 886 mm above the floor (one foot above the end table) appears to indicate a very low reading along with some negative readings. Therefore, it was concluded that the meter was not working properly.

The oxygen concentration data collected, only five values because of the power outage, showed the concentration as a constant 20.9 percent. Therefore the data was discarded.

III. Acknowledgments

The guidance and direction provided by Dr. Robert Levine, technical monitor for this project, is appreciated. The cooperation of the Maryland Fire and Rescue Institute staff is invaluable. Funding for this work was shared by two agencies, the Bureau of Alcohol, Tobacco, and Firearms (ATF) of the U.S. Department of Treasury, and the National Institute of Justice (NIJ) of the U.S. Department of Justice. ATF support was arranged by Ms. Jackie Herndon, Director of Career Development. NIJ funds were transferred as part of the program of the National Institute of Standard and Technology office of Law Enforcement Standards, Ms. Kathleen M. Higgins, Director. Efforts by the following students are recognized: Mr. Thomas Woodford, Mr. Mark Aaby, Ms. Dorethea Bailey, Mr. Thomas Brown, Mr. Jeff Dudley, Ms. Stacy Neidhart, Mr. John Ordile, Mr. Mike Six, Ms. Brooke Strehlen, and Mr. Andrew Weisfield.

Test 13

Diagram of Furnishings and Instrumentation for Test 13, September 19, 1996

Figure 1.1

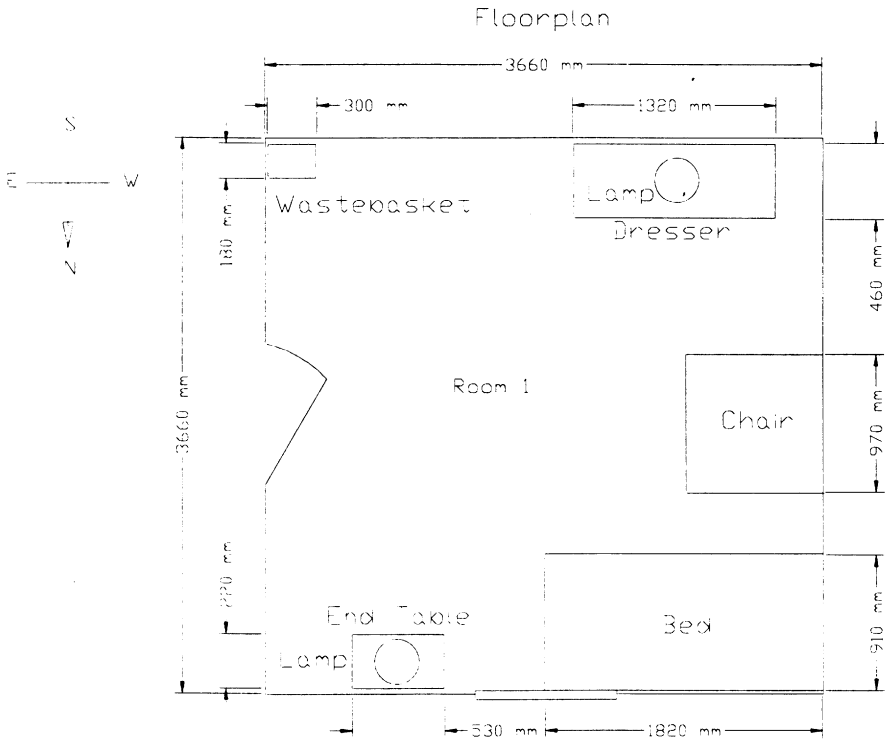


Figure 1.2

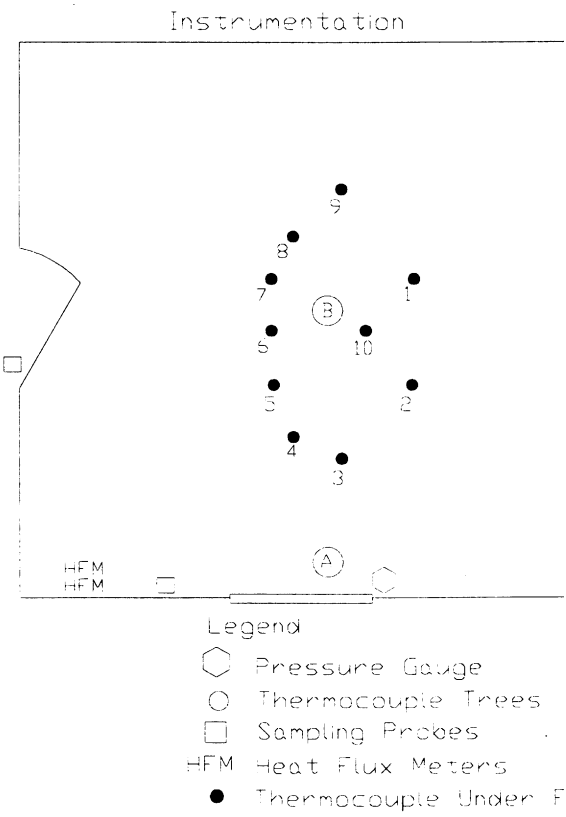


Figure 1.3

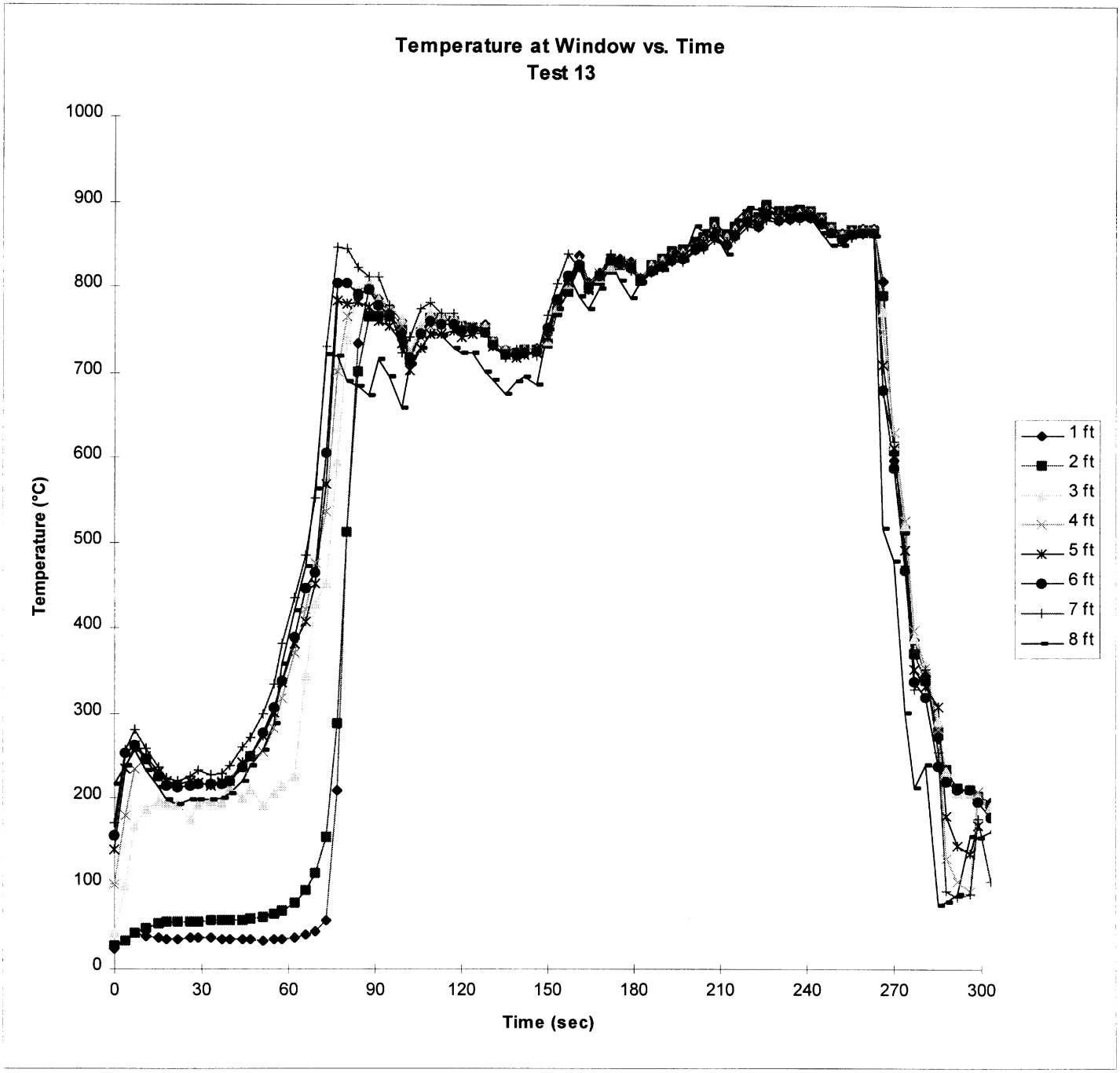

Temperature at Window vs. Time
Test 13
Temperature (°C)
1000
900
800
700
600
500
400
300
200
100
0
0
30
60
90
120
150
180
210
240
270
300
Time (sec)
1 ft
2 ft
3 ft
4 ft
5 ft
6 ft
7 ft
8 ft

Figure 1.4

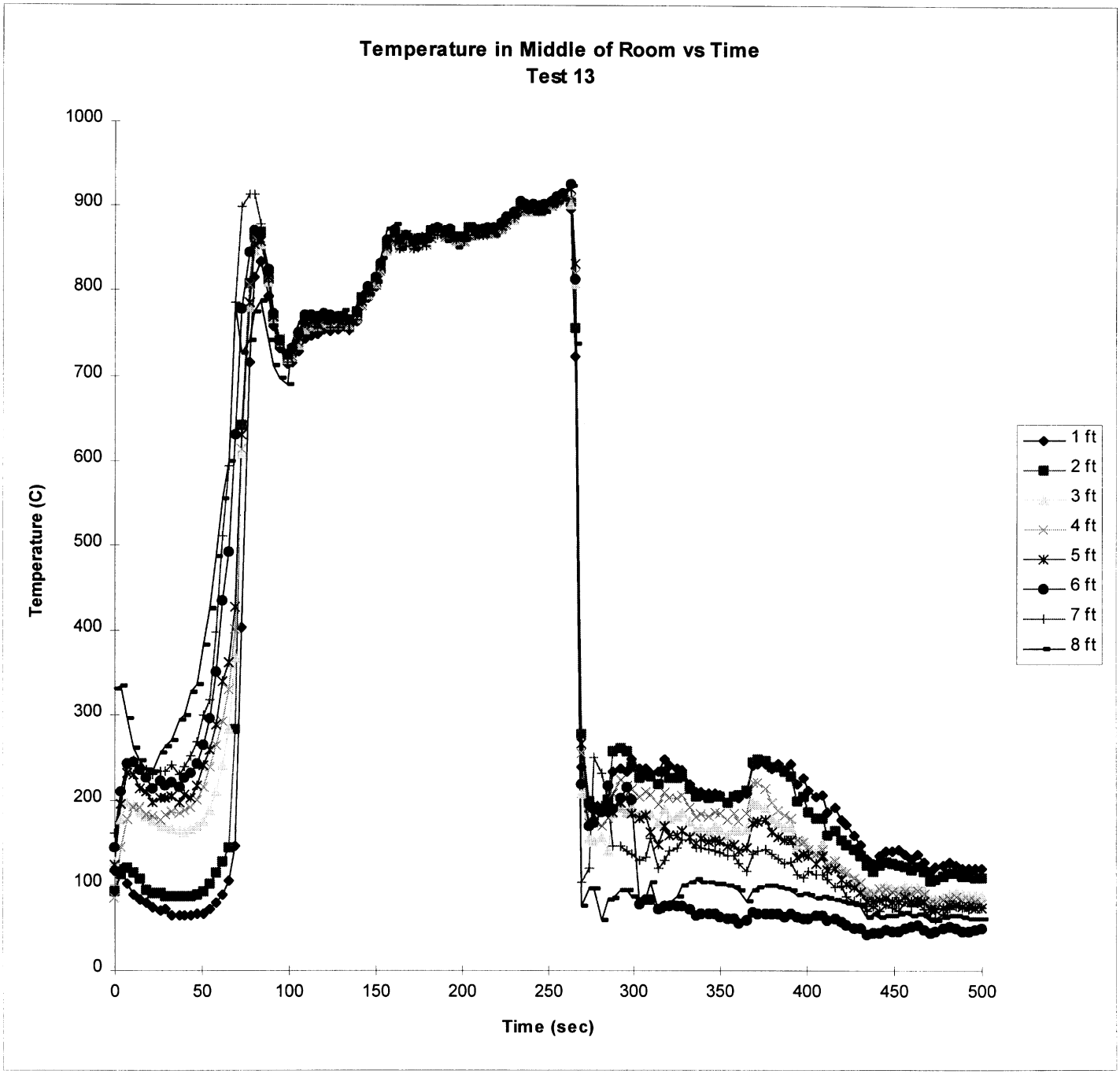

Temperature in Middle of Room vs Time
Test 13
Temperature (C)
Time (sec)
1000
900
800
700
600
500
400
300
200
100
0
0
50
100
150
200
250
300
350
400
450
500
1 ft
2 ft
3 ft
4 ft
5 ft
6 ft
7 ft
8 ft

Figure 1.5

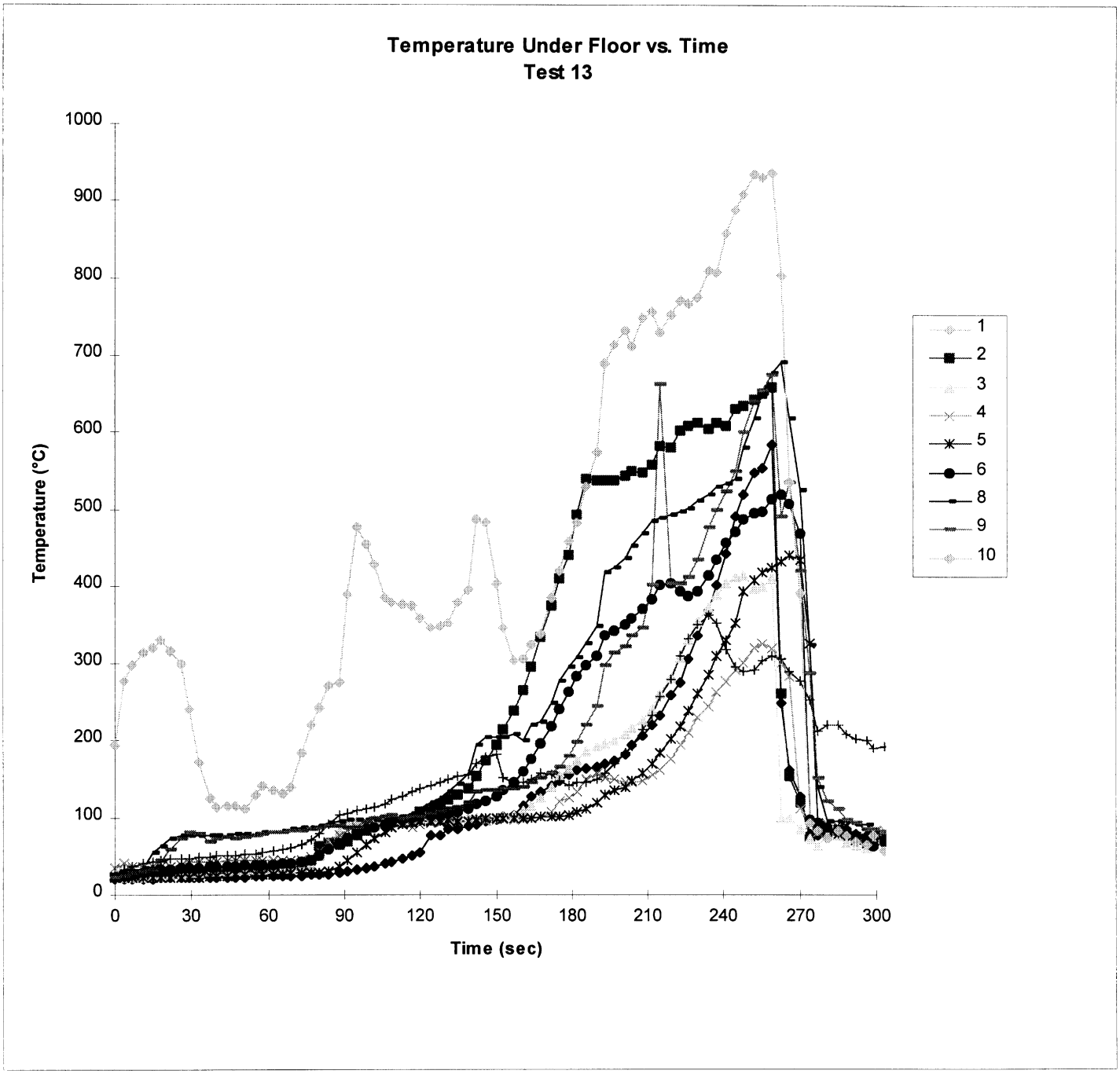

Temperature Under Floor vs. Time
Test 13
Temperature (°C)
1000
900
800
700
600
500
400
300
200
100
0
0
30
60
90
120
150
180
210
240
270
300
Time (sec)
1
2
3
4
5
6
8
9
10

Figure 1.6

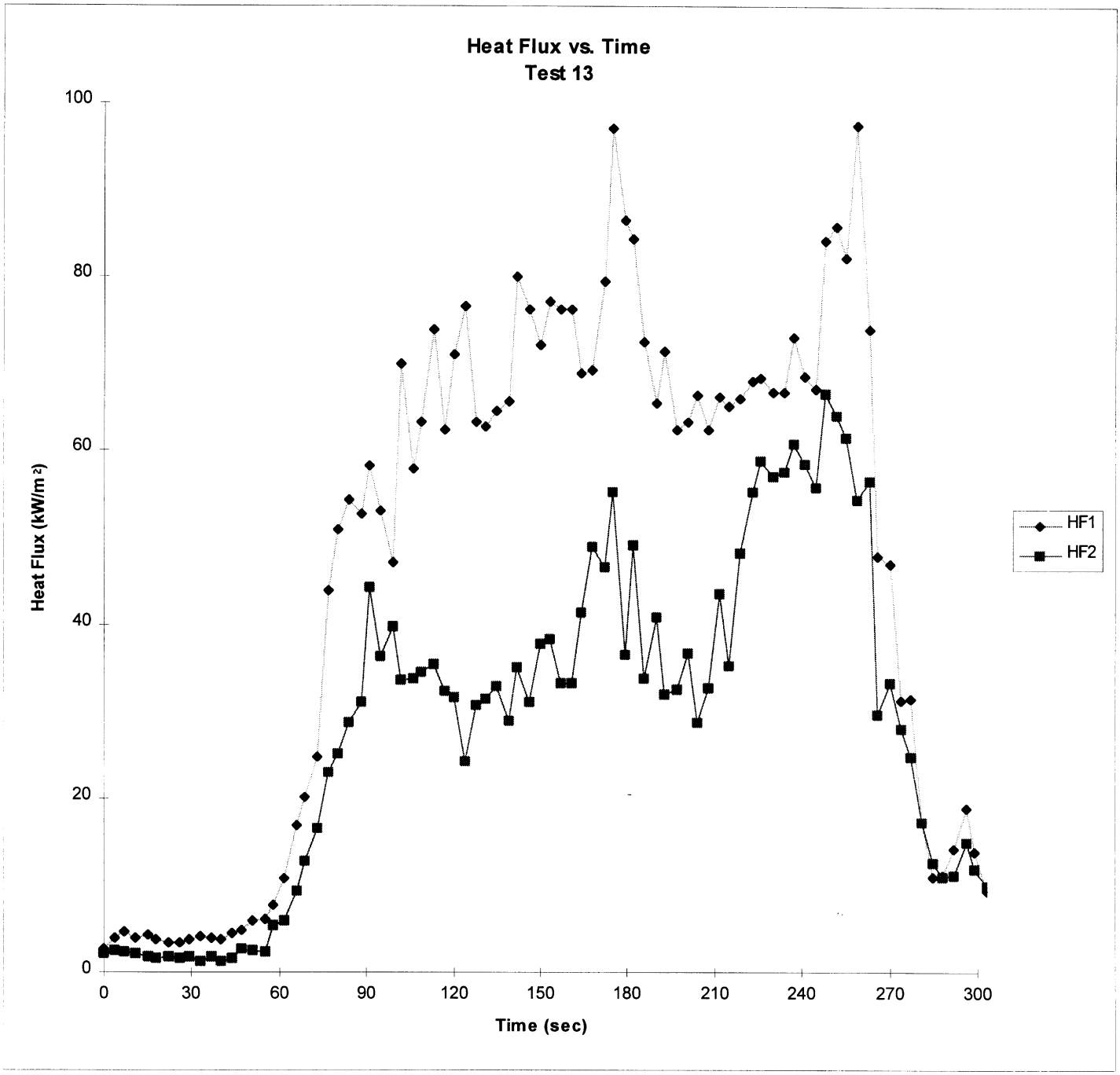
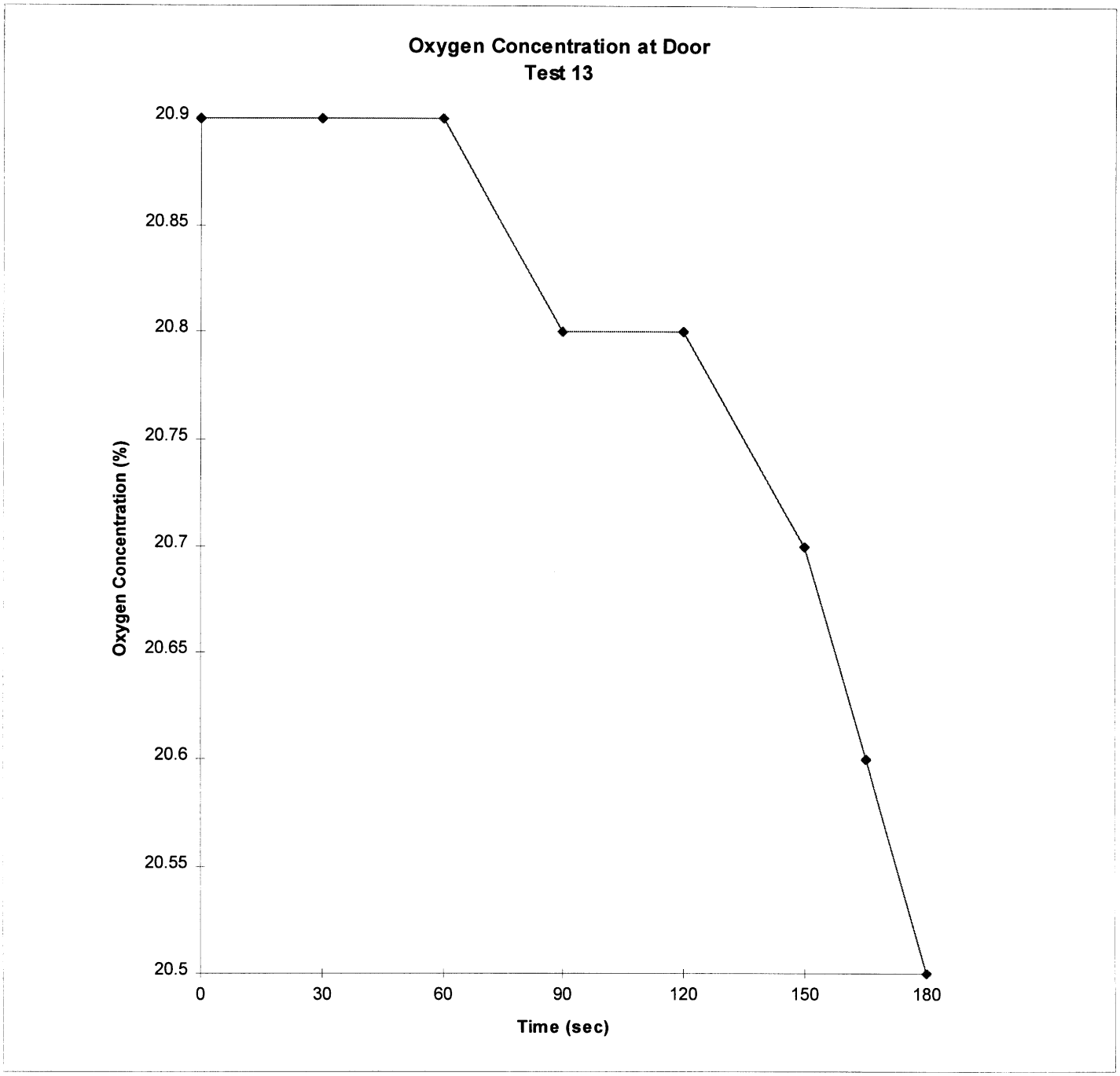

Heat Flux vs. Time
Test 13
Heat Flux (kW/m²)
100
80
60
40
20
0
0
30
60
90
120
150
180
210
240
270
300
Time (sec)
HF1
HF2

Figure 1.7


Oxygen Concentration at Door
Test 13
Oxygen Concentration (%)
20.9
20.85
20.8
20.75
20.7
20.65
20.6
20.55
20.5
0
30
60
90
120
150
180
Time (sec)

Test 14

Diagram of Furnishings and Instrumentation for Test 14, September 19, 1996

Figure 2.1

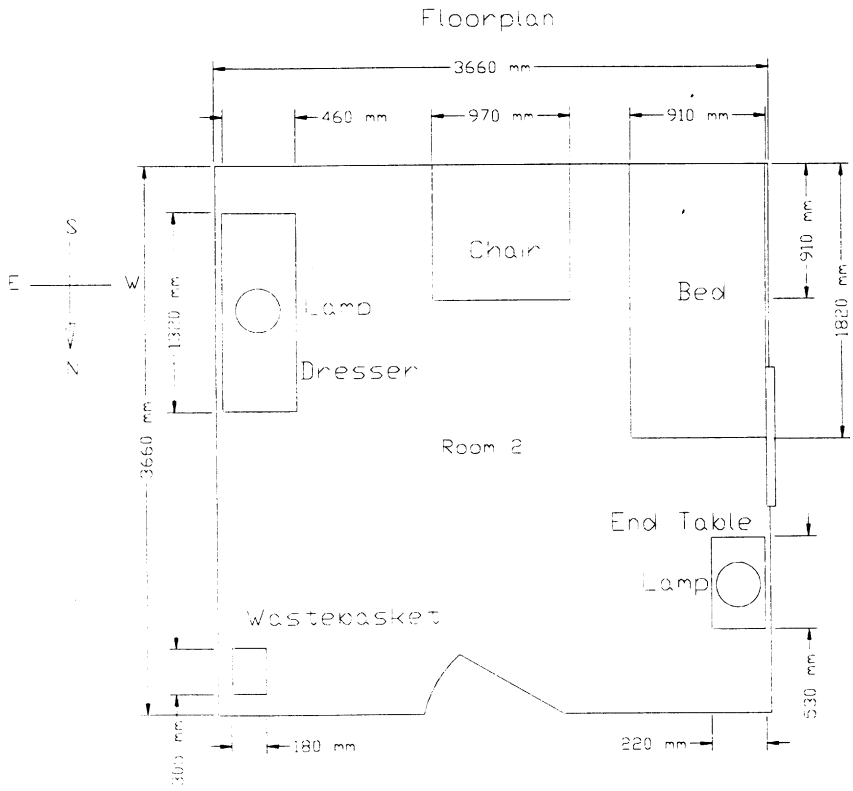


Figure 2.2

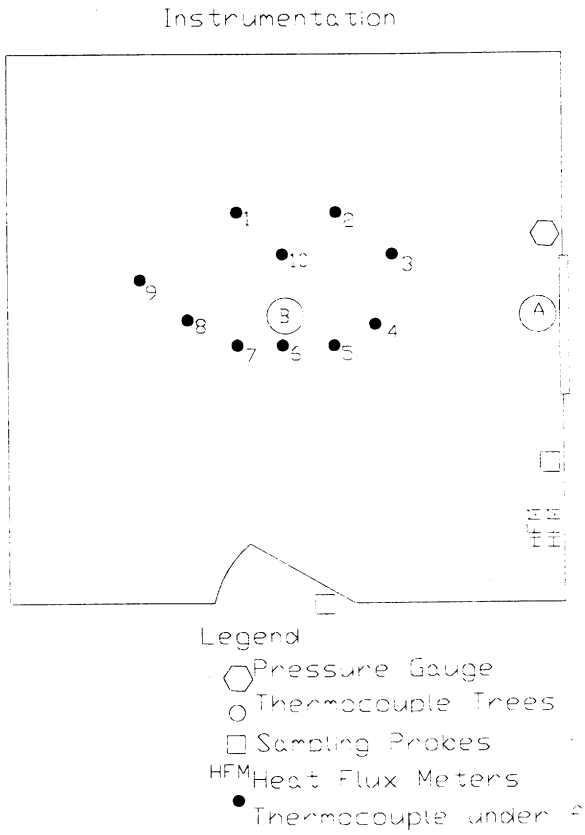


Figure 2.3

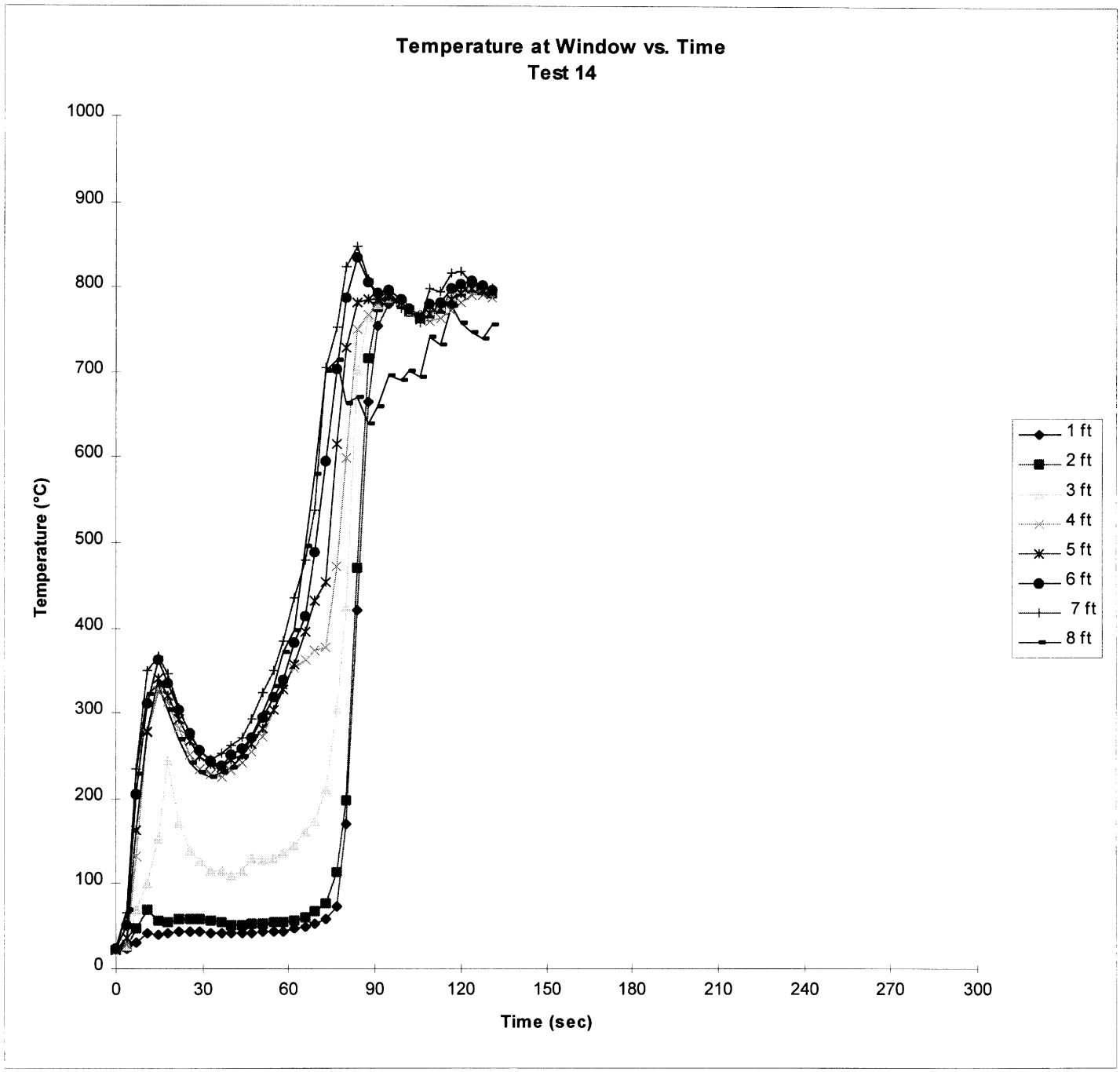

Temperature at Window vs. Time
Test 14
Temperature (°C)
1000
900
800
700
600
500
400
300
200
100
0
0
30
60
90
120
150
180
210
240
270
300
Time (sec)
1 ft
2 ft
3 ft
4 ft
5 ft
6 ft
7 ft
8 ft

Figure 2.4

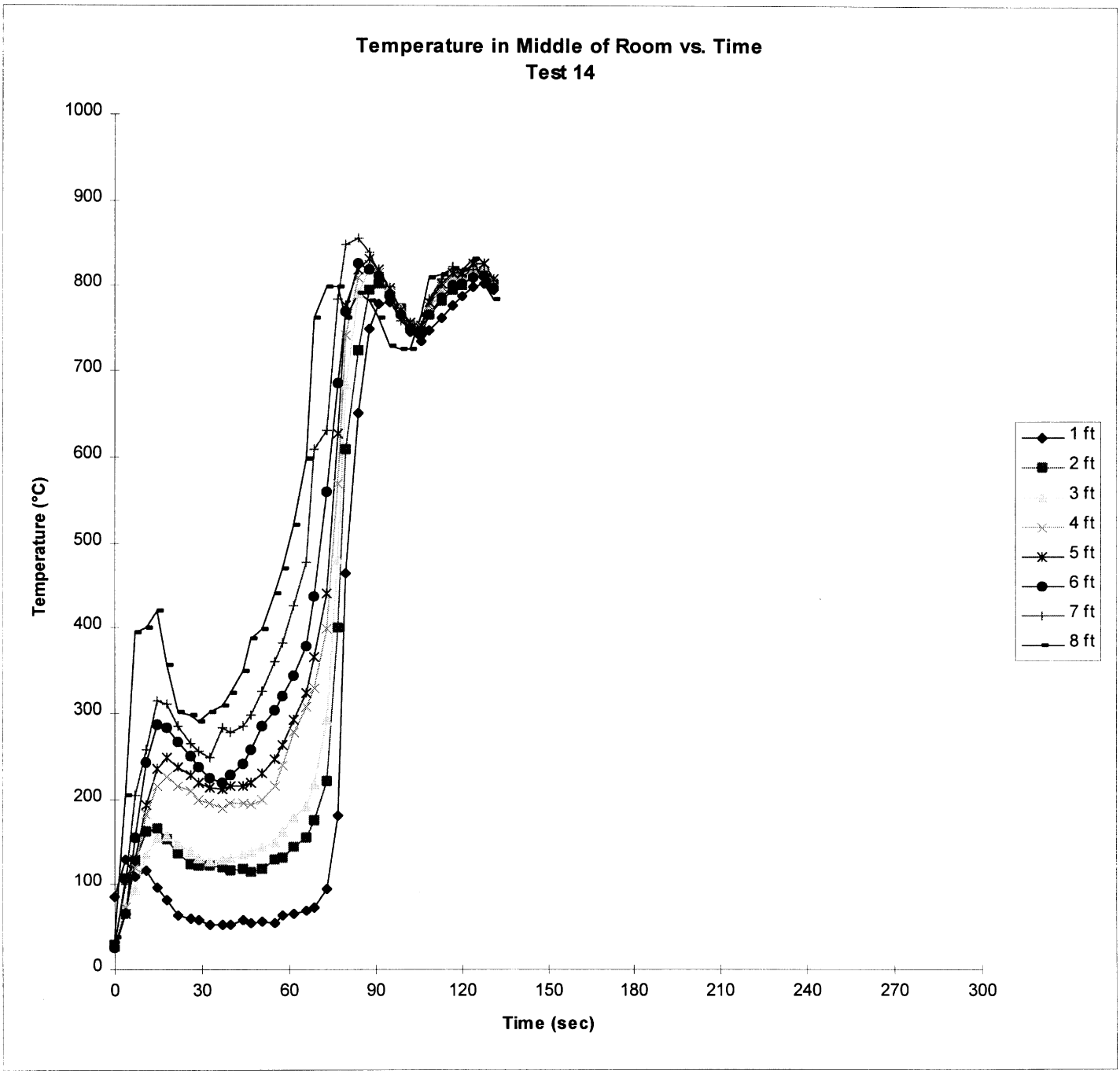

Temperature in Middle of Room vs. Time
Test 14
Temperature (°C)
1000
900
800
700
600
500
400
300
200
100
0
0
30
60
90
120
150
180
210
240
270
300
Time (sec)
1 ft
2 ft
3 ft
4 ft
5 ft
6 ft
7 ft
8 ft

Figure 2.5

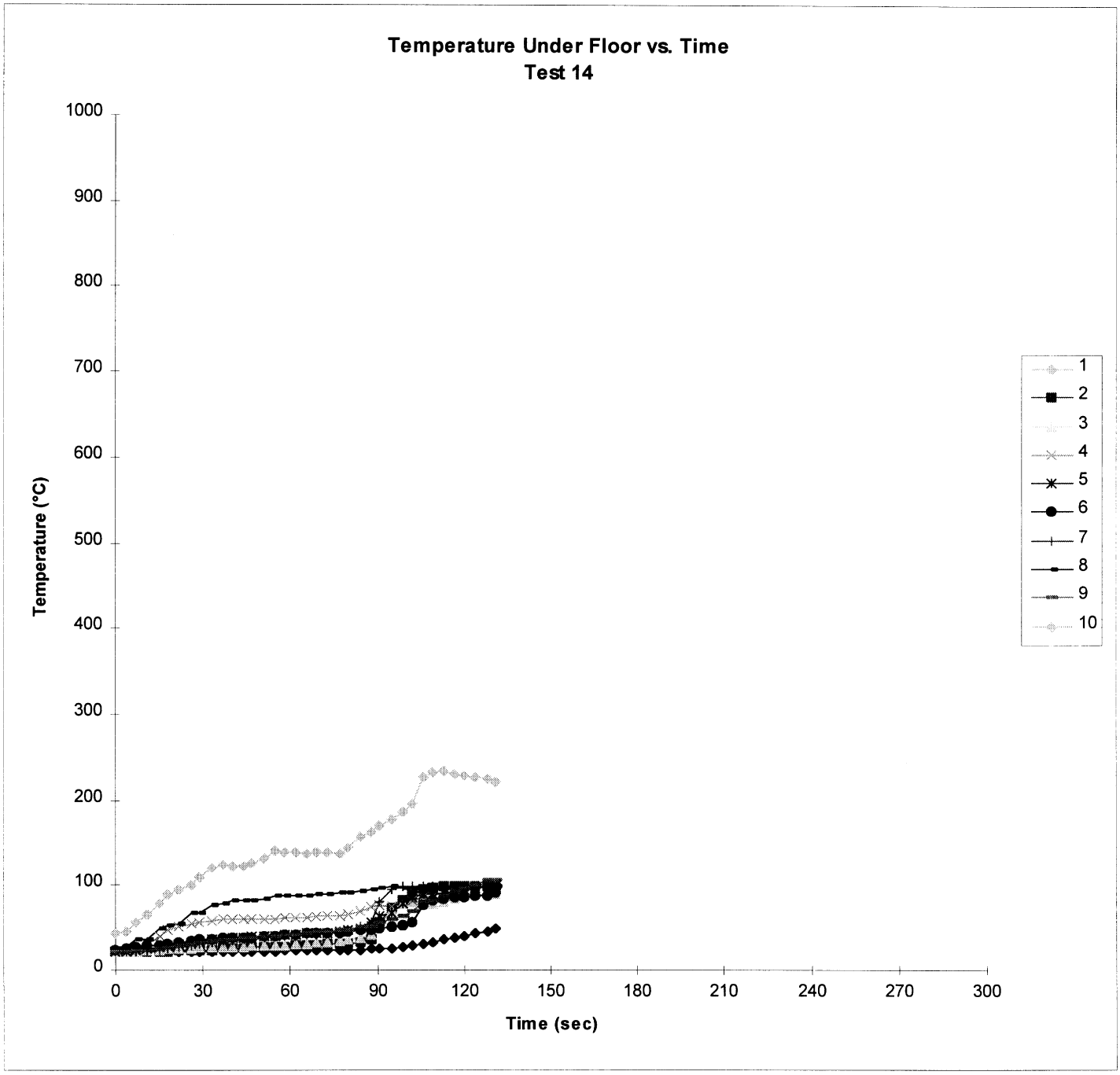

Temperature Under Floor vs. Time
Test 14
Temperature (°C)
1000
900
800
700
600
500
400
300
200
100
0
0
30
60
90
120
150
180
210
240
270
300
Time (sec)
1
2
3
4
5
6
7
8
9
10

Figure 2.6

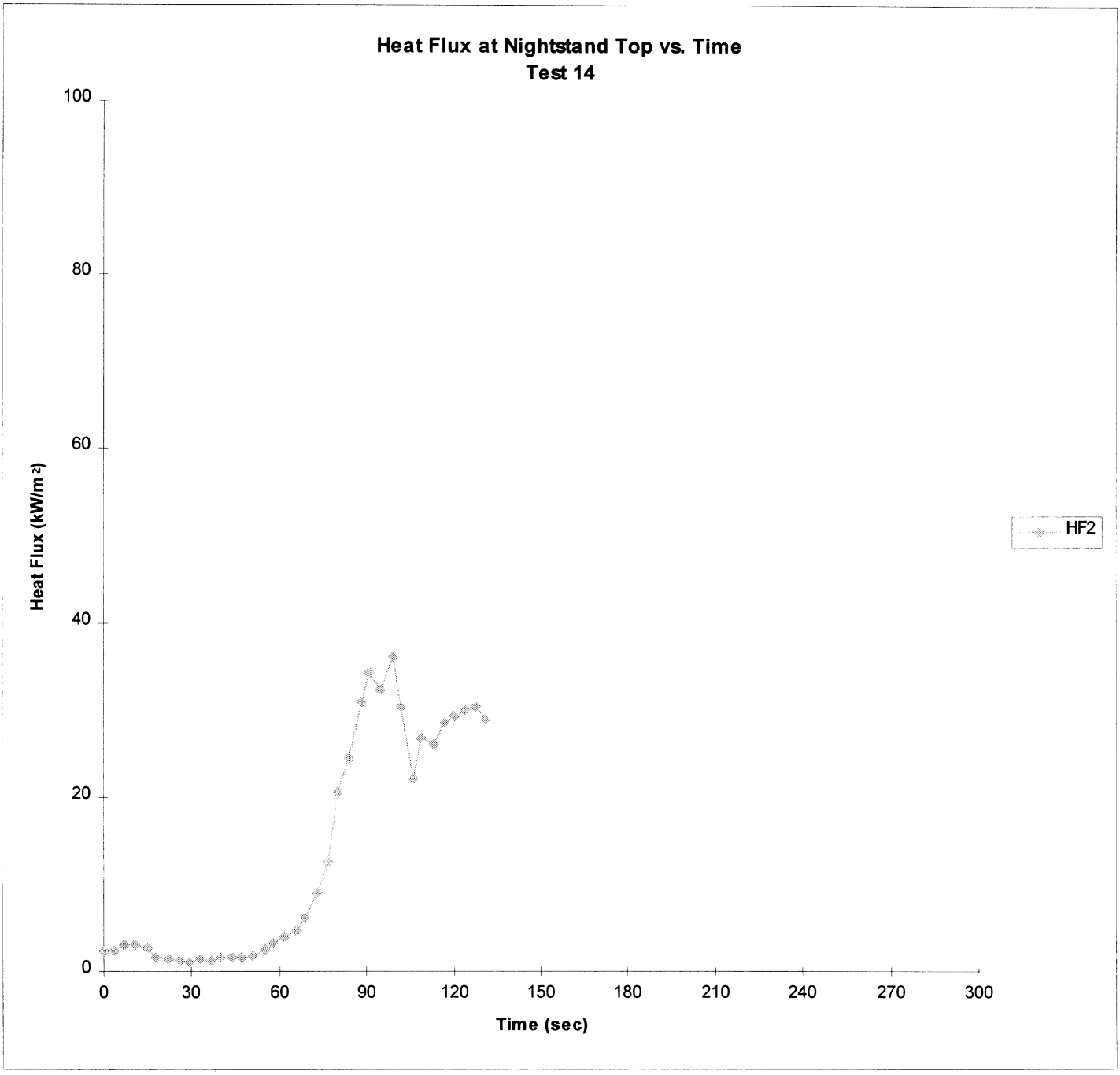
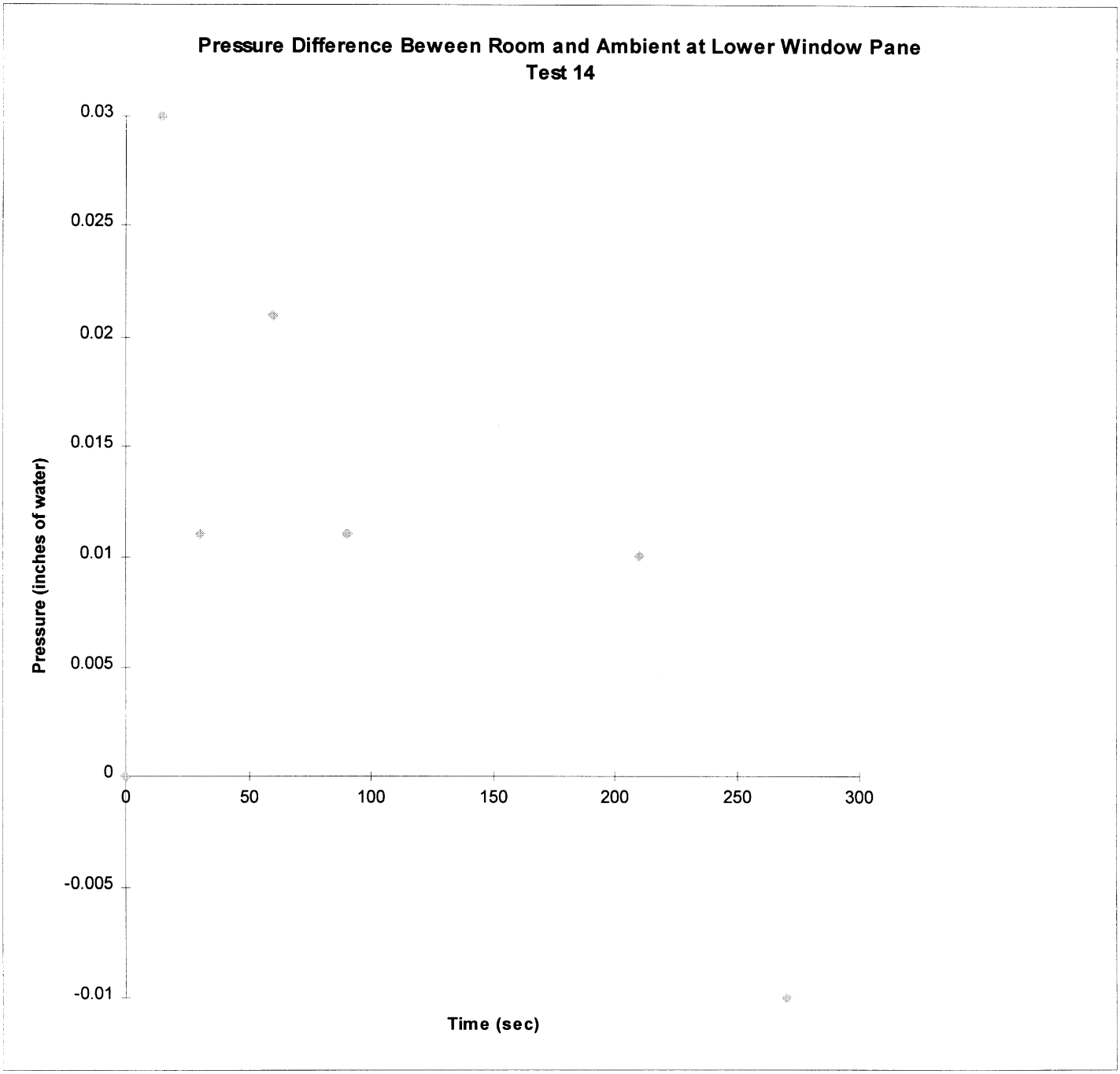

Heat Flux at Nightstand Top vs. Time
Test 14
Heat Flux (kW/m²)
100
80
60
40
20
0
0
30
60
90
120
150
180
210
240
270
300
Time (sec)
HF2

Figure 2.7


Pressure Difference Beween Room and Ambient at Lower Window Pane
Test 14
Pressure (inches of water)
0.03
0.025
0.02
0.015
0.01
0.005
0
-0.005
-0.01
0
50
100
150
200
250
300
Time (sec)

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Two full-size furnished bedrooms were burned, September 19, at the University of Maryland Fire and Rescue Institute Facilities These burns were performed for two cooperating agencies; the Alcohol, Tobacco and Firearms Agency of the Treasury Deparatment who used them as part of their Certified Fire Investigator training, and the Building and Fire Research Laboratory of the Nationa Institute of Standard and Technology, who used them for forensic research. It was intended that these two burns be identical, to see i close analysis of the results would find differences. Some differences were noticed possibly due to small differences in the inflow c ventilation air. In both cases, ignition of a gasoline spill next to an upholstered chair was used to initiate the fire. This repor describes the test arrangement and instrumented results.

KEY WORDS (MAXIMUM OF 9; 28 CHARACTERS AND SPACES EACH; SEPARATE WITH SEMICOLONS; ALPHABETIC ORDER; CAPITALIZE ONLY PROPER NAMES)
compartment fires; fire investigation; fire research; flashover; gypsum board; large scale fire tests; measuring instruments; oxygen concentration; room fires; upholstered furniture

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